

Fig. 2. Simulated ascent booster failure for both HL-20 and SHARP-V5 on a 51-degree inclination orbit.

Slender Hypersonic Aerothermodynamic Research Probe Ballistic Flight Experiment B2

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The Slender Hypersonic Aerothermodynamic Research Probe Ballistic Flight Experiment B2 (SHARP-B2) was the second ballistic flight experiment in which the behavior of ultrahigh-temperature ceramic composite (UHTC) materials in a hypersonic flight environment was investigated. As in SHARP-B1, the SHARP-B2 flight experiment was a collaborative effort of Ames Research Center, Sandia National Laboratories, and the U.S. Air Force. The primary objective of the SHARP-B2 flight experiment was to investigate the aerothermal and thermal structural performance of the

UHTC materials near their aerothermal performance constraints, for example, their maximum single-use and multiple-use temperatures. A secondary objective was to recover the UHTC components to observe their condition after a hypersonic ballistic reentry.

Ames is investigating UHTC materials as an enabling technology for the development of reusable launch vehicles with sharp leading edges. Vehicles with sharp leading edges are desirable because of their potential for significant improvements in aerodynamic performance, lift-to-drag ratio (L/D), compared with

the current reusable launch vehicle, the space shuttle orbiter, which has a relatively blunt leading edge. The enhanced aerodynamic performance of a vehicle with sharp leading edges will lead to improved crew safety by increasing the window during ascent when a safe abort to ground can be performed and by increasing the cross-range of the vehicle, thus increasing the number of landing sites available during descent.

Significantly higher heating occurs on sharp leading edges during hypersonic flight than on blunt leading edges like those on the space shuttle. Therefore, if launch vehicles with sharp leading edges are to be used, new materials capable of withstanding these high temperatures must be developed. UHTCs are a family of ceramic materials with very high melting temperatures and good oxidation resistance in reentry environments. Ground-based arc-jet testing has demonstrated the potential of these materials in reusable applications at temperatures approaching 4,000°F; thus they offer the potential to develop passively cooled sharp leading edges.

The components flown on SHARP-B2 were much closer in geometry to what would be considered a sharp leading edge (see fig. 1)

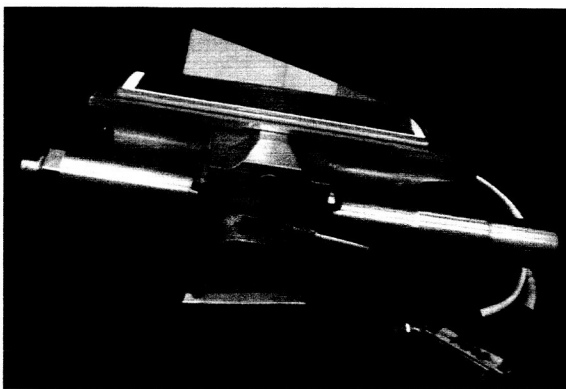


Fig. 1. UHTC strake.

than the axisymmetric nose tip flown on SHARP-B1. The strakes, as the UHTC components are referred to, are made of three segments, and each segment is composed of a different UHTC material, thus making it possible to investigate the performance of three different materials during a single flight experiment. Four strakes were equally spaced around the reentry vehicle and were split into two pairs; one strake in each pair was instrumented with sensors to measure the temperature within the strakes. The temperature was then correlated with the vehicle's altitude and velocity and compared with preflight predictions. The strakes were designed so each pair would be retracted at a specified altitude.

Figure 2 shows the SHARP-B2 mission scenario. The reentry vehicle was carried on a Minuteman III and was launched from Vandenberg Air Force Base on 28 September 2000. During reentry the strake pairs were retracted at predetermined heights based on aerothermal predictions of when the aft sections of the strakes would reach their multi- and single-use temperature limits. A parachute was then deployed to minimize the impact velocity in the Kwajalein atoll lagoon in the west Pacific. The reentry vehicle, with the retracted strakes, was then recovered.

The SHARP-B2 flight experiment provided a tremendous amount of data on both the strakes' aerothermal environment as well as the thermal and mechanical properties of the UHTC materials. Postflight analysis is providing invaluable information for future flight experiments. Recovery of the strakes demonstrates the need for postflight characterization of flight articles to facilitate materials development.

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